No. 7.—*Line in the Indigo at or near G*

ALVAN CLARK, JUN.	At 435 ; assumed to be 434 G hydrogen.
PROCTOR.	At 121 ; *more* refrangible than Hγ (114) ; coincident with a line (of oxygen ?) in lumière tube. Probably there is some error here ; this line as positioned by Lord Lindsay and Alvan Clark, jun., being slightly *less* refrangible than G.—J. R. C.
LORD LINDSAY.	Slightly less refrangible than G ; a broad, ill-defined band, seen only with a wide slit.

The continuous Spectrum

T. F. (Torquay).	Faint from about D to beyond F.
FLÖGEL. (Schellen).	Faint green reaching from aurora line to F.
SCHMIDT. (Schellen.)	From aurora line to F ; frequently resolved into three bright lines.
ZÖLLNER. (Schellen.)	Considers the bright lines or bands Nos. 4, 6, and 7 to be a continuous spectrum broken up by dark absorption bands.

Guildford, Nov. 9 J. RAND CAPRON

Ocean Rainfall

WITH reference to Mr. Miller's note (NATURE, vol. vii. p. 123), I think it may be desirable to point out that a good many steps have been taken in the direction he suggests. As I believe Mr. Miller is a reader of "British Rainfall," he will probably hardly need to be reminded of the article on "Ocean Rainfall," by Mr. F. Gaster in the volume for 1866, wherein tables of the *prevalence* of rain in the North and South Atlantic and North Pacific Oceans are given in considerable detail. The determination of the amount is a far more difficult matter for a number of reasons, which would require much space fully to explain, and I am not at all surprised at the feat being considered "impossible ;" but the use of that word is becoming restricted. At the British Association meeting at Brighton, Mr. W. T. Black was kind enough to show me a rain gauge which he had had constructed somewhat on the plan described by him in the *Journal of the Scottish Meteorological Society* for January 1870, and which he intended should make a few voyages on purpose to test.

With respect to gauges on lightships, I may state that at my suggestion the Elder Brethren of the Trinity House allowed a gauge to be placed upon the *Nore* lightship in the autumn of 1865. It was carefully observed by the officers on board for about two years, and the returns were compared with simultaneous records kept at Sheerness on the Kentish, and Shoeburyness on the Essex coast. I cannot say that I was satisfied with the results, which were principally vitiated by spray and wind. The gauge was bolted rigidly to a post on the deck of the vessel, as I then thought this preferable to the incessant oscillations which would result from the employment of gimbals

Considering the sources of inaccuracy attaching to the measurement of rainfall at sea, and the fact that, so far as I am aware, lightships are seldom more than ten or twenty miles from land, I think that there are few cases in which they could render valuable aid.

As to the *Challenger* I know nothing ; but I do know that it was the joint resolution of Mr. Black and myself each and both to do what we could towards obtaining quantitative records of the rainfall of the North Atlantic, and when last I heard from him there were prospects of partial success. Only partial because we do not hope or expect to ascertain the true fall, but merely the relative fall in different zones, or portions of the ocean.

Camden Square, London G. J. SYMONS

INTRODUCTORY LECTURE OF THE MURCHISON CHAIR OF GEOLOGY AT EDINBURGH, SESSION 1872-3*

II.

MUCH has recently been said (so much, indeed, that the subject begins to get somewhat wearisome) regarding the necessity for wide-spread scientific instruction to enable our artisans to compete with the advancing industry of foreign countries. Technical education has become a kind of political cry, like the county franchise or women's electoral disabilities. We hear, continually, too, of the need for a more special training in science for such professional pursuits as those of the engineer and the military officer, or of the men who devote themselves to the task of geographical discovery. Far be it from me to say one word that would seem to imply an undervaluing of such practical applications of science. Most heartily do I wish that a technical school were established in every great town in the country, and that every man whose pursuits in life might call for the aid of science, should have the means of obtaining sound practical instruction in those branches likely to be of service to him.

But I cannot believe that such utilitarian views, important though they undoubtedly are, set before us the true place which science ought to hold, and which I am convinced it will one day hold in the general system of education in this country. Scientific culture is something more than a weapon to help us in the keen warfare of trade and commerce. It is, in truth, itself a noble form of education, filling a place which can be filled by none other, and without which no modern culture of the higher type can now rightly claim to be regarded as liberal.

It is this aspect of the subject which I seek to impress upon your minds to-day. I do so the more readily since it seems to me that your presence as members of this voluntary class is a token that you recognise with me the desirability of adding to the traditional methods of education. The matters which will come to be dealt with here lie outside of the ordinary curriculum of study. Yet they form part of that wider field which must ere long be conjoined with the older territories as the domain now to be required for higher culture.

Apart altogether from any practical application to be made of a scientific training for the active business of life, such a training seems to me to deserve and require a place in our ordinary system of education on several grounds, of which I shall at present notice only two—firstly, because it trains the observing faculty ; and, secondly, because it stimulates the imaginative faculty.

I. Taking the lowest view of the case, it will not be denied that a habit of quick and accurate observation is one of the most advantageous powers with which a man or woman can be equipped. Such a habit often makes all the difference between a successful and an unsuccessful career. In point of actual hard-thinking power a man may be greatly superior to his fellows, but this power is not enough of itself alone to ensure success in the battle of life. Much must ever depend on the rapidity and shrewdness with which passing events are noted and provided for ; or, in other words, the care with which the observing faculty is cultivated as well as the judgment.

But beyond and above such considerations we cannot doubt that the observing spirit carries about with it a multiplied power of enjoyment—so multiplied, indeed, that, placed beside the unobserving spirit, it seems almost to have been gifted with another sense. A well-trained power of observation never suffers its possessor to feel wholly alone. Even out of the most solitary scenes it can gather pleasant companionship, and amid the ordinary monotonous routine of life it finds recreation where, in its absence, men are apt to encounter only dulness. The story of our childhood—"Eyes and no Eyes"—has in this respect a significance for people of all ages as well as for schoolboys.

If you think of it you will probably find that what we ordinarily term *common sense* springs in no small measure out of this habit of observation. A man who is wont to keep his eyes open and take note of the changes continually going on around him, both among men and things, is more likely to acquire just views of the business of life than a man who takes notice only of what forces itself upon his attention.

From the moment of our birth we are surrounded by phenomena which demand our attention, and many of which will brook no neglect. We learn what heat is, not by the instruction of mother or nurse, but by the memorable experience of scalded tongue or burnt finger. The idea of distance grows upon us as our infant hands struggle in vain to grasp the picture on the farther wall, or to reach the moon. The notion of weight dawns upon our minds as the toy falls from our loosened grasp to the floor. In these and other ways Nature herself is our teacher; and we learn rapidly enough when not to do so involves us in continual physical suffering.

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* Continued from p. 165.

In our journey through life thousands of objects impress themselves on our mere outward eyes, yet are never really observed by us. Nay, they may actually in some degree reach the inner eye, and yet from want of training, or ignorance, or carelessness, we may never see these things as they essentially are, or as they would be seen by one whose observing faculty had been duly cultivated.

Some years ago I had an amusing illustration of this familiar fact in the case of a cottager in Ayrshire who stopped me on the high-road near his own door, late one autumn evening, to show me a will-o'-the-wisp. Never having had the good fortune to encounter one of these legendary sprites, I was naturally curious to see and hear about this example. I was told that it appeared in damp breezy weather in autumn and spring, usually in the evening, and never anywhere else than over the rubbish heaps of a deserted coal-mine. The light seemed, indeed, to my rather sceptical eyes strangely like the flicker of cottage windows seen behind some waving trees; but my informant assured me that he had watched the thing for fully thirty years, and could not be mistaken. Leaving him at his cottage, I made straight across a succession of fields and fences, and soon reached, in the fading twilight, the mound at the old coal-mine. There, however, I sought in vain for will-o'-the-wisp; but about a quarter of a mile farther on, on the other side of a strip of wood, now visible, now concealed, as the leaves happened to be stirred by the wind, were the flickering lights of a row of cottages. My friend had noted the lights, had even correctly enough connected their flickering with breezy weather; but his observations had gone no further, and so for thirty years he was content with an hallucination which he could at any time have dispelled in five minutes.

Many men never get very much further in their questioning and experiment of the external world than that degree of child-like experience which enables them to keep themselves from bodily harm or to obtain the means of bodily enjoyment. If this habit of observation be not already born and active in them the usual discipline of modern education does little to engender or quicken it. They are left to learn the use of their eyes as they best may, or to pass through life without ever learning to use them at all. There is still no special training in the cultivation of the observing faculty—a training not to be taken or left at the expense of parent or scholar, but which shall be an essential and imperative part of education.

Nevertheless, though this great faculty is left to such scanty collateral influences as it may receive from the already-authorised lines of instruction, it is as certainly capable of cultivation and improvement as any other part of our mental organism—nay, upon its proper cultivation much of our welfare and of our highest pleasure depends. Surely it is not too much to demand that a faculty to which the present epoch of human history owes in especial measure its characteristics, shall be recognised as one of the parts of our nature to be sedulously cared for in the instruction of youth?

Among the reforms of the future one will assuredly be the supplying of this defect in our present system of education. And in no way can this be so advantageously done as by the practical teaching of some branch of natural science. We may not increase the army of scientific discoverers, and there is no need that we should; but we shall at all events equip each man and woman with better armour for the battle of life, adding vastly at the same time to their capacity for some of the purest pleasures which are obtainable in this world.

2. Whatever tends to stimulate the imaginative faculty, taking us out of the routine of daily life, and enabling us to realise times and conditions different from those in which we live, helps to raise us in the dignity of thinking beings. This faculty is well cultivated by some parts of the traditional system of education. Literature, notably history and poetry, afford endless materials for this purpose. These materials deal largely with questions having a more or less distinctly human interest. Nevertheless, though man is himself the proper study of mankind, his conceptions cannot fail to be enlarged when he is brought face to face with a whole world of phenomena lying outside of himself and his experience. Such enlargement it is one of the tasks of science to ensure.

You will find it sometimes gravely asserted to be "a deviation from the correct use of language and a confounding of things essentially distinct to say that a man of science stands in need of imagination as well as powers of reason." I hope that before long you will perceive the fallacy of such an assertion and recognise the necessity of imagination not in the man of science only, but in every one who would adequately master the aims and results of scientific thought. Imagination, that is, the power of shaping in our minds a distinct picture of what from many observations of facts we determine to be the plan of nature, either now or in the past, lies at the very bottom of all thorough scientific research. Without imagination to gather them all up into a luminous conception, the scattered observations of countless independent workers would lose half their meaning, and indeed would often never be made at all, for in many cases they are themselves the suggestion of imagination. To deny to Science the use of this faculty would be to clip her wings, to forbid her to soar into the highest heavens, and to condemn her to a mere ant-like industry upon this nether earth.

In adding to the present curriculum of a liberal education some training in scientific habits of mind and work, we should in no wise deaden or hamper the free use of the imaginative faculty. On the contrary, we should furnish it with the complement of that anthropomorphic or subjective method of viewing things which mere literary training is apt to produce We should enable it to take a freer, wider grasp of creation and of man's place therein.

[The speaker here illustrated his argument by an example drawn from the geology of the neighbourhood of Edinburgh.]

Now this is but an ordinary and simple example of the kind of mental processes through which geology requires us to pass. There seems little worthy of note on a group of moss-grown lichened stones on a bare hill-side; yet the observing faculty, once put on the alert, readily detects the singularity of these boulders, sets about its task of gathering all the information to be gleaned regarding them and of preparing a body of evidence to be weighed and decided upon by the judgment. And then arises the imaginative faculty with its power of reproducing the past. Under its sway woodland and cornfield seem to melt away before us, the hills are once more sealed in ice, and fleets of boulder-laden bergs come drifting over what are now the fertile plains of the Lothians.

While, therefore, in the work which lies before you here it will be your endeavour to add to your knowledge, do not lose an opportunity of cultivating at the same time these two faculties. So long as your knowledge is merely from books, so long as you are content with a kind of mere cramming, such an opportunity will be little likely to occur. It is when you turn your knowledge to account and seek for illustration or expansion of it by direct personal appeal to Nature that your powers of observation and imagination will have free play.

Fortunately we meet in a district rich in incentives to appeals of this kind. Every crag and dell around seems to beckon us to its side that it may set problems before us for solution. Part of the work of the winter will lie in availing ourselves of these opportunities. We shall make visits to the hills and quarries of the neighbourhood, and test the lessons of the lecture-room by actual seeing and handling of the rocks.

Thus, while we gain larger conceptions of the structure and history of the planet on which we dwell, we shall at the same time perform no unimportant part in that long education which, though it stands out more prominently in our earlier years, is not less surely the business of our lives.

THE RECENT STAR SHOWER

A CONSIDERABLE number of exact determinations of the place of the radiant-point of the shooting stars recorded during the recent meteoric shower have during the last few days continued to reach me, of which the accompanying general list and a rough outline map (Fig. 2) will, perhaps, best convey the general result at present arrived at regarding this important point in connection with the astronomical character of its appearance. That the stream of meteors, originating in the materials of Biela's comet, pursue, in a current of great length and thickness, nearly the same orbit as that of the comet round the sun, may be clearly concluded from the many observations of the meteor shower which have now been brought together. Among the most interesting of the descriptions relating to this subject is a report by Dr. Heis, of Münster, in Westphalia, of the observations made at that observatory between 8h. and 9h. P.M., and of others which he received from distant places, of the frequency of the meteors at that and at later periods of the night. The number seen by two observers at Munster, in fifty-three minutes, between 8h. and 9h. P.M., was 2,200 meteors, 400 of which appeared in the last interval but one of six minutes before 9 o'clock, or about forty-two per minute during the whole time. At the Göttingen Observatory 7,710 meteors were counted in three hours, giving nearly the same average of frequency during the greater portion of the shower. At Svanholmsminde, in the north of Jutland, Mr. S. Tromholdt recorded, with the assistance of two observers, 600 shooting stars in the first quarter of an hour after 9 o'clock, or about forty per minute, as observed at Munster. Allowing at the latter place thirty minutes, and in Jutland forty minutes, as their longitudes in time, east from Greenwich, the great abundance of the meteors here noted nearly coincides with the second principal maximum of the shower seen by Mr. Lowe and by Prof. Grant, at Glasgow, to have occurred at about, or shortly after, 8 o'clock. From the same time until 11h. 30m. P.M. (10h. 50m. Greenwich time), Mr. Tromholdt counted 1,660 meteors in two hours and a half, indicating a greatly decreased intensity of the shower; and, although clouds then prevented further observations, a perfectly clear sky enabled him to resume them at half-past 4 o'clock A.M. (3h. 50m. Greenwich time) on the morning of the 28th, when he found the display to have entirely ceased, only four shooting stars making their appearance during the hour between half-past 4 and half-past 5 o'clock, or about 4 o'clock, Greenwich time.

In NATURE, vol. vii. p. 86, the observations of Mr. W. Swan, at St. Andrews, show that the termination of the shower had actually arrived at an earlier hour on the morning of the 28th, since, the sky being quite clear at half-past 1 o'clock A.M., no shooting stars could then be seen. A writer on the appearance of the shower at Dublin informs me that his observations fully corroborated this result, for, on looking out at about 1 o'clock (Irish, or nearly half-past 1 o'clock Greenwich time), the number of meteors was found to have diminished to about one in two or three minutes, and during a quarter of an hour after about half-past 2 o'clock, Greenwich time, not a single shooting star appeared in sight, although there was then always sufficient clear sky to enable one observer to have an uninterrupted field of view of the constellations. Both the extent of the densest portion and the limits of the extreme boundary of the stream are excellently marked by these valuable observations. There appears without doubt to have been a period of nearly uniform maximum intensity, lasting from shortly after 6 to shortly before 8 o'clock P.M., in which one observer might, under the most favourable circumstances, count from fifty to a hundred meteors per minute, or on an average about one meteor per second. The duration of this period seems to have been about an hour and a half, its centre occurring at about, or very shortly after, 7 o'clock. For about two hours after it, the shower lessened so gradually as not to fall much below a quarter of its maximum intensity until nearly 10 o'clock, but from that time it continued to decline so rapidly that soon after midnight one observer scarcely counted so many as one meteor per minute, and by 2 o'clock A.M. it had entirely disappeared. Taking its gradual rise before 7 o'clock to have been similar to its rate of diminution afterwards, and the whole time of its visibility to have been divisible into periods of two hours each, of which the central one, of greatest intensity, occurred between 6 and 8 o'clock P.M., and three others, on either side of this, might be distinguished as copious, conspicuous, and hardly more than ordinary meteoric displays, it is easy to estimate, from the known inclination at which the earth's path crosses the axis of the stream, the thickness of the meteoric stratum which it traversed in each of these successive periods. The actual width or transverse thickness of each of these meteoric strata must have been about 50,000 miles, and that of their whole sum, consisting of seven such periods, was about 350,000 miles. The diameter of the visible nebulosity of Biela's comet, as it was observed in telescopes, was estimated at 40,000 miles, and the nearest approach of its orbit to that of the earth, in 1832, was computed to be about 17,000 miles, so that the thickness of the meteor stream which the earth passed through on Nov. 27 last, exceeds these calculated dimensions by very many times. That it was, however, not the tail, or envelope, of the comet through which the earth passed, but a stream of particles left behind the nucleus of the comet on its track, was pointed out by a Dutch observer, and writer on the astronomical features of the shower (Herr Van de Stadt), in the *Arnhemsche Courant*, referred to in NATURE, vol. vii. p. 86. He founds this on the consideration that if, as the most probable calculations by Mr. Hind of the comet's path at this return inform us, it passed its perihelion on or about Oct. 6 last, and therefore, through its node, and its nearest point of approach to the earth's orbit about Sept. 14 last, it must, at the time of the occurrence of the meteor shower, have advanced some 250,000,000 miles, or about a seventh part of the whole circumference of its orbit along its path, having already passed its perihelion, and proceeded nearly as far as the orbit of the planet Mars in its subsequent departure from the sun, and its distant approach towards the opposite part of its orbit from the earth.

Projecting all the meteor-tracks which were recorded from my point of view, at Newcastle-upon-Tyne, upon a plane perspective chart of the constellations, a very evident centre of divergence of the shower from a space round a spot in R.A. 20°, N. Decl. 40°, is very clearly shown by the backward prolongations of the tracks, about 60 per cent. of which pass within 4° or 5° of this place. Many of the tracks recorded were somewhat widely erratic, coming chiefly from a more northerly